ADT PLM

Programmer's Learning Machine

Matthieu Nicolas

COAST meeting, 2016-02-12

Outline

1. Presentation of PLM
   - Purposes
   - Demo
   - About PLM
   - Architecture
2. To a web app
   - Goals
   - Server-side
   - Client-side
3. Assessment of user's code
   - Challenges
   - Extraction of the execution component
   - Docker
4. Result
5. Next steps

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Presentation of PLM

Purposes

- Application to learn programming.

Presentation of PLM

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- Allows students to progress at their own speed...

Presentation of PLM

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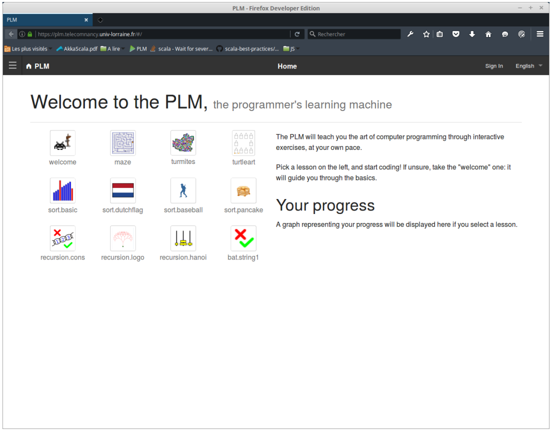
- Allows students to progress at their own speed...
- ... while the teacher helps the ones having trouble.

Presentation of PLM

Purposes

- Application to learn programming.
- Allows students to progress at their own speed...
- ... while the teacher helps the ones having trouble.
- Used at TELECOM Nancy since 2008.

Presentation of PLM
Quick demo



Welcome to the PLM, the programmer's learning machine

The PLM will teach you the art of computer programming through interactive exercises, at your own pace.

Pick a lesson on the left, and start coding! If unsure, take the "welcome" one: it will guide you through the basics.

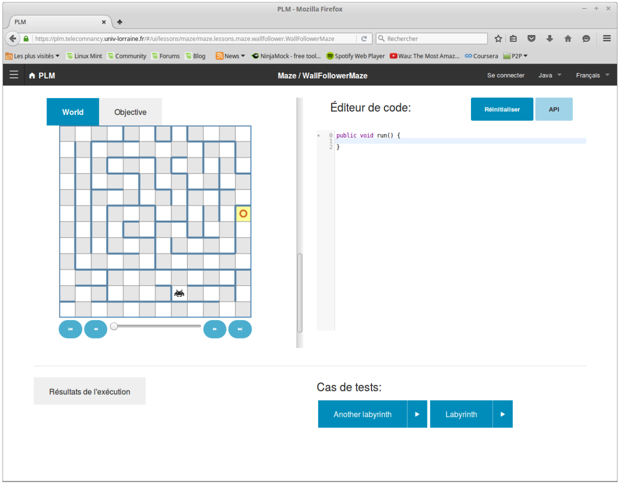
Your progress

A graph representing your progress will be displayed here if you select a lesson.

- Available at `https://plm.telecomnancy.univ-lorraine.fr`

Presentation of PLM

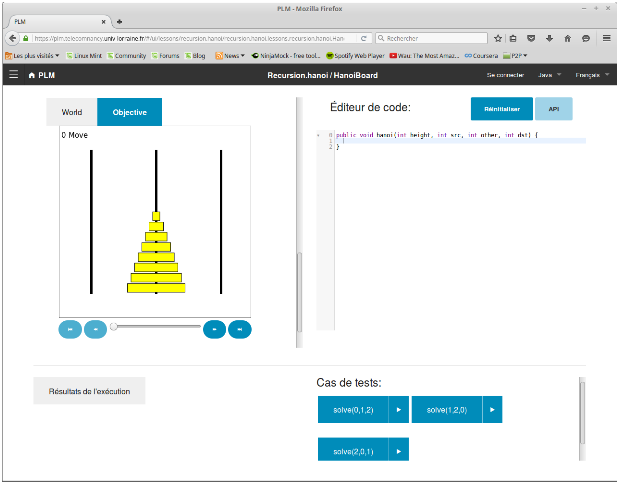
12 lessons, 200 exercises



```
public void run() {
}
```

Presentation of PLM

12 lessons, 200 exercises

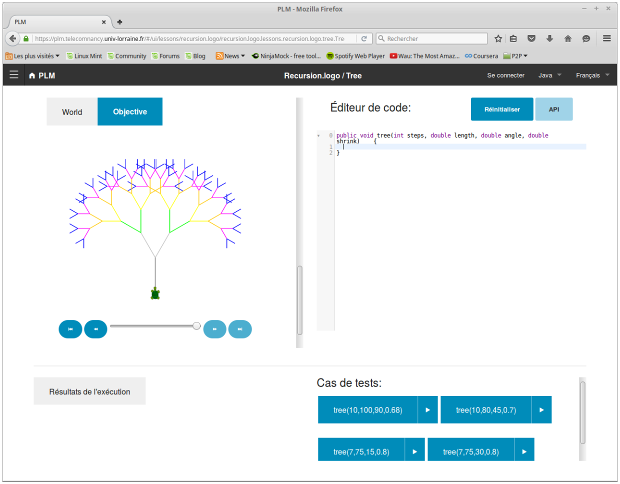


```
public void hanoi(int height, int src, int other, int dst) {

}
```

Presentation of PLM

12 lessons, 200 exercises



Éditeur de code:

```
public void tree(int steps, double length, double angle, double
shrink)    {
  
}
```

Cas de tests:

- tree(10,100,90,0.68)
- tree(10,80,45,0.7)
- tree(7,75,15,0.8)
- tree(7,75,30,0.8)

Presentation of PLM

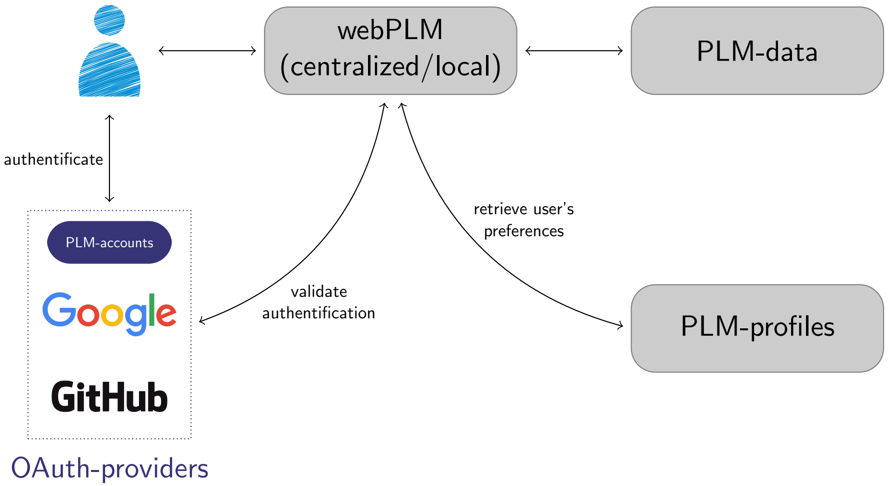
Languages and programming languages

- Available languages:
  - English
  - French
  - Brazilian Portuguese
- Supported programming languages:

Java Scala python™

Presentation of PLM

Application's architecture


webPLM (centralized/local)
PLM-data
authentificate
PLM-accounts
Google
GitHub
OAuth-providers
validate authentification
retrieve user's preferences
PLM-profiles

Presentation of PLM

A word about PLM-data

- Keep track of the users' progress...

Presentation of PLM

A word about PLM-data

- Keep track of the users' progress...
- ... using a git repository

Presentation of PLM

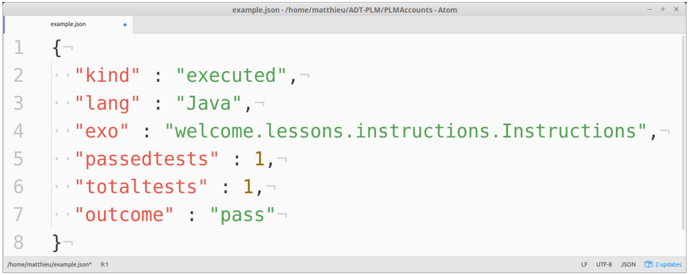
How does it work?

- Store users' code versions

Presentation of PLM

How does it work?

- Store users' code versions
- Store users' actions as commit messages


example.json - /home/matthieu/ADT-PLM/PLMAccounts - Atom
example.json
/home/matthieu/example.json* 9:1
LF UTF-8 JSON 2 updates

```
{
  "kind" : "executed",
  "lang" : "Java",
  "exo" : "welcome.lessons.instructions.Instructions",
  "passedtests" : 1,
  "totaltests" : 1,
  "outcome" : "pass"
}
```

- Working in anonymous branches
- Branches pushed to a **GitHub** repo

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To a web app

Evolution of the project

- Formerly a fat client
    - Written in Java

To a web app
Evolution of the project

- Formerly a fat client
  - Written in Java
- Switch to a web application
  - Server implemented in Scala using *PlayFramework*
  - User interface written in Javascript using *AngularJS* and *Foundation*

To a web app

Motivations

- Want to switch to SaaS[1]
  - Easy to use
  - Easy to update
  - Easy to track usage data
- More user-friendly
- Aim to setup SPOC[2] and MOOC[3]

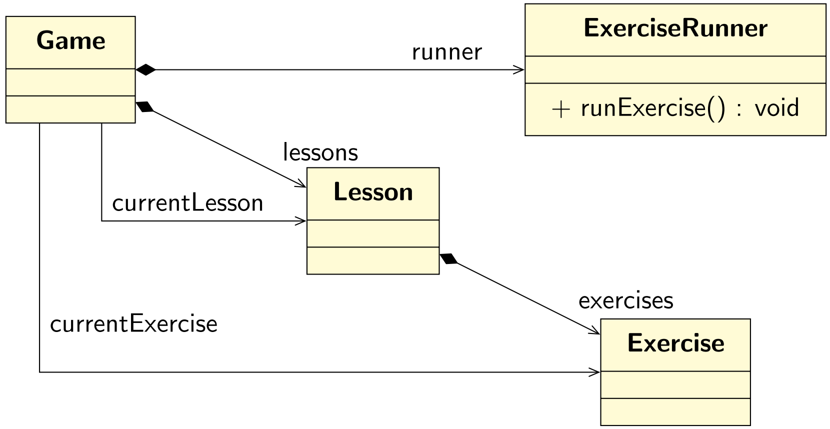
- But don't have the time and means for a reboot

[1] Software as a Service
[2] Small Private Online Course
[3] Massive Open Online Course

To a web app

Refactoring PLM

- Implemented a headless version of PLM: *PLM-engine*
  - Provide all PLM's content and methods
  - But without a user interface



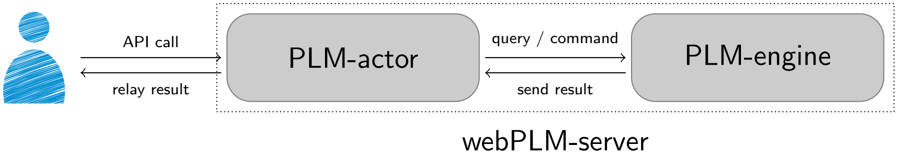
To a web app

Implementing the server

- Designed an API over PLM-engine
- Only need to implement a controller
  - Verify calls received from the client
  - Query or command PLM-engine according to the call
  - Send back result or acknowledgement to the client

To a web app

Interactions between components

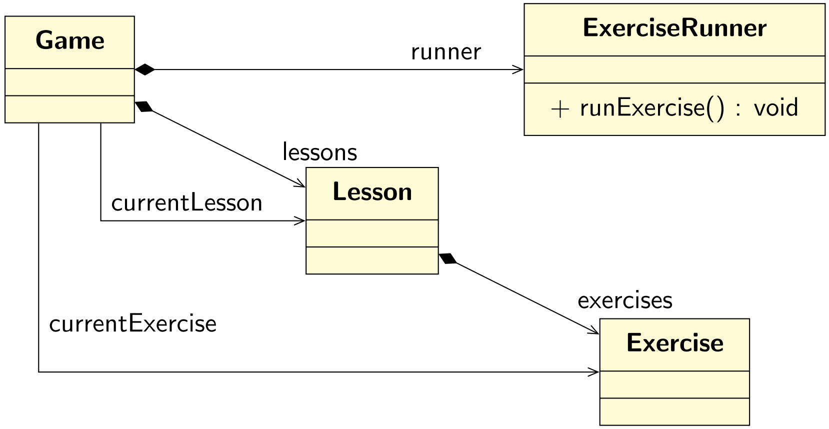


To a web app
Dealing with multi-user

- **Game** is a *singleton*

To a web app
Dealing with multi-user

- **Game** is a *singleton*
- Do you remember that we store the user's session in **Game**?



To a web app

Removing the singleton **Game**

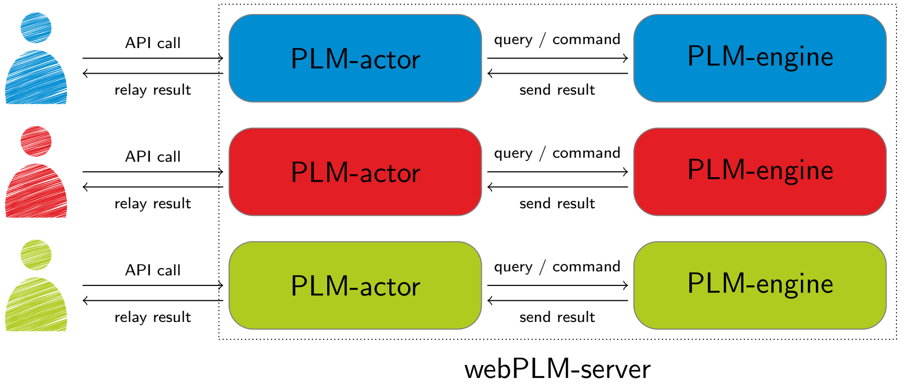
- Need to refactor all components accessing it

To a web app
Removing the singleton **Game**

- Need to refactor all components accessing it
- Let's save it for later!
- Add **Game** as constructor's parameter

To a web app

Multi-user scenario

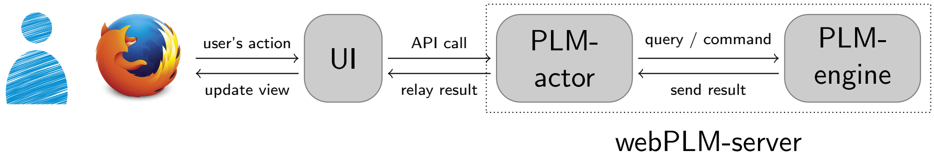


To a web app
Results

- Build quickly a web server from the fat client...
- ... but we also need a user interface

To a web app

Adding the user interface



To a web app

- Have to translate user's actions into API calls
- Have to re-implement PLM-engine's data models

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Assessment of user's code
Limits

- Run on the same machine, same JVM

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- How to protect ourselves from users' rookie mistakes?
    - Infinite loops

Assessment of user's code
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- Run on the same machine, same JVM

- How to protect ourselves from users' rookie mistakes?
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- And from more malicious "mistakes"?
    - Infinite thread creation
    - Endless file creation

Assessment of user's code
Limits

- Run on the same machine, same JVM
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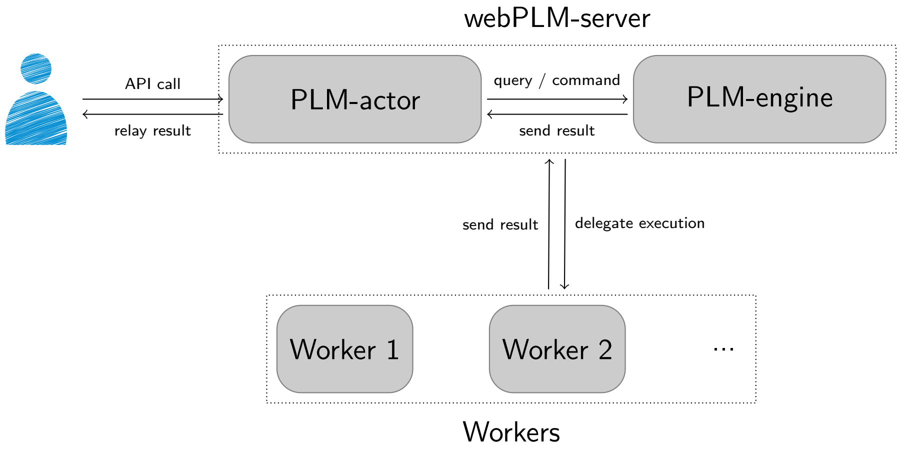
- And from *System.exit(whatever)*?

Assessment of user's code
Limits

- Run on the same machine, same JVM
- How to protect ourselves from users' rookie mistakes?
  - Infinite loops
- And from more malicious "mistakes"?
  - Infinite thread creation
  - Endless file creation
- And from *System.exit(whatever)*?
- Scalability issues

Assessment of user's code
Chosen solution

- Delegate execution to workers



Assessment of user's code

The judges

- Called *Judges* in the litterature
- Use PLM-engine as well

- Workflow:
  - Retrieve an execution request
  - Parse the request to extract parameters
  - Configure PLM-engine according to them
  - Run the user's code
  - Send back result to webPLM

Assessment of user's code
Message queues

- Message-driven architecture
- Loosely coupled system
- Asynchronous/Synchronous
- Help to implement:
  - Producer/Consumer pattern
  - Request/Response pattern
- Different reliability patterns of the message processing:
  - Only one worker
  - At least one worker
  - All workers
- Easy to scale

Assessment of user's code

Message queues

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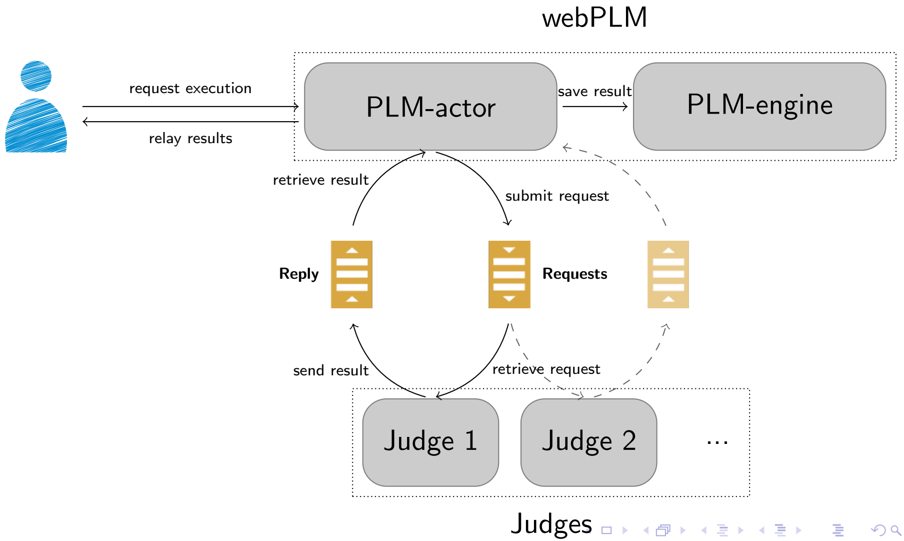
Assessment of user's code

Architecture with judges



Assessment of user's code

Pros and cons

- Pros:
  - Allow to run code without impacting webPLM's performances
  - Meet the scalability requirements

Assessment of user's code

Pros and cons

- Pros:
  - Allow to run code without impacting webPLM's performances
  - Meet the scalability requirements
- Cons:
  - Make sure to use the right version of PLM-engine
  - Need to deploy them easily
  - Should restart them after each execution
  - Have to restrict their resources usage

Assessment of user's code

Docker

- Lightweight virtualization tool
- Build image of your application
- Run containers based on images

Assessment of user's code

Docker in our case

- Deploy easily all components
- Restart judges automatically
- Limit judges' ressources

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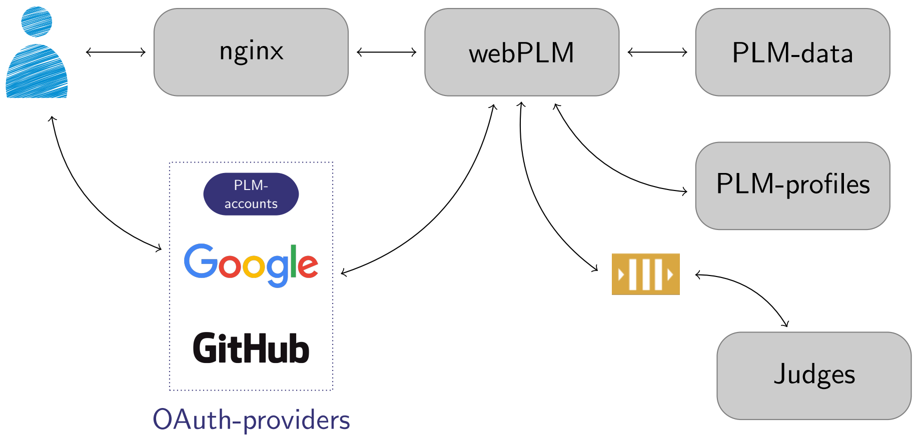
Result

Current architecture



Result

Live-session in TELECOM Nancy

- Rushed to release a stable version before the start of the school year
- Used in TELECOM Nancy in September 2015
- 30 hours of live testing with 100 students

Result
Live-session in TELECOM Nancy

- Rushed to release a stable version before the start of the school year
- Used in TELECOM Nancy in September 2015
- 30 hours of live testing with 100 students

- Engine is (almost) working fine...
- ... but user experience needs to be improved!

Result

Live-session in TELECOM Nancy

- Scalability issues:
  - Work well with small exercises
  - Can't cope with workload of larger exercises

Result

Live-session in TELECOM Nancy

- Scalability issues:
  - Work well with small exercises
  - Can't cope with workload of larger exercises
- No tools for monitoring set up...

Result

Live-session in TELECOM Nancy

- Scalability issues:
  - Work well with small exercises
  - Can't cope with workload of larger exercises
- No tools for monitoring set up...
- ... so the bottleneck is unknown.

Result
Refactor the code

- Needed to clean some parts of the code before further building
- Merged local and centralized mode branches

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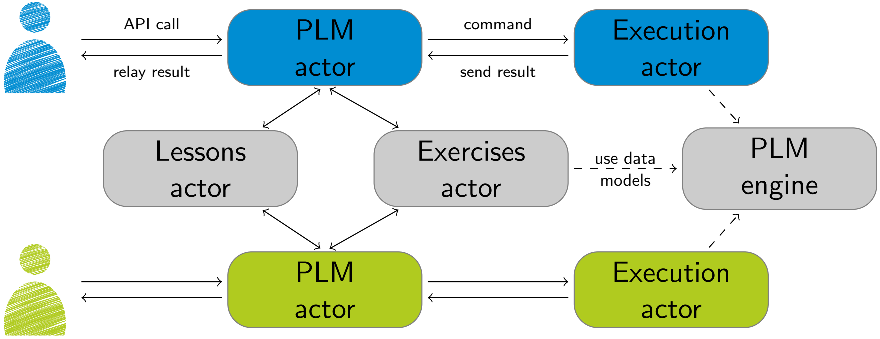
Extract components from PLM-engine

- Most components are inside PLM-engine
- Updating PLM-engine $\rightarrow$ new version of webPLM and Judge
- Heavy and error prone workflow



- Allow to implement an exercise editor

Next steps

Solve performance issues

- Set up some monitoring tools
- Perform some load testing to identify the bottleneck

Next steps

Sneak peek from the TODO list

- Integrate interns' contributions
- Set up Continuous Deployment
- Support additional programming languages
- Implement a debug mode similar to popular IDEs' ones
- Add features to help teachers to supervise their students
- ...

Questions

Thanks for your attention, any questions?